Appendix K

On-Site Domestic Wastewater Treatment in the Lake Helena Watershed

Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report

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Prepared for the Montana Department of Environmental Quality

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Contents

1.0 Introduction

On-site domestic wastewater from privately owned septic systems is one of the largest sources of nitrogen and phosphorus to Lake Helena and many of its tributary streams. This document provides a summary of the state and local regulations regarding septic systems, a review of the literature regarding treatment efficiency of conventional and alternative septic systems, and a comparison of cost and treatment efficiency for a variety of septic system designs.

2.0 State and Local Regulations

In Montana, the state, cities, and counties have the authority to regulate subsurface wastewater treatment systems (SWTS). The regulating authorities in the Lake Helena watershed are the State of Montana, Lewis and Clark County, and Jefferson County. The role of the three entities differs based on the type, location, size, and purpose of the wastewater treatment system.

Small, privately owned onsite treatment systems must meet the design requirements specified in Montana Department of Environmental Quality (MDEQ) Circular 4 (Montana Standards For Subsurface Wastewater Treatment Systems), and the rules and prohibitions described in the Administrative Rules of Montana (ARM) 17.36.9 (On-Site Subsurface Wastewater Treatment Systems). However, the counties (i.e., Lewis and Clark County and Jefferson County) issue permits and inspect all small, privately owned systems. Counties may also require system upgrades and issue fines for existing out of compliance systems.

Lewis and Clark County also has more stringent regulations than contained in ARM 17.36.9. Regulations are based on the type of soils and depth to groundwater, and in some cases require pressure dosed or level 2 treatment (Lewis and Clark County, 2006). Jefferson County regulations are the same as the state regulations, and are no more stringent. By meeting the regulations specified in Circular 4 and ARM 17.36.9, most small onsite systems, by default, meet the criteria for creating a “non-significant” change in water quality, and a nondegradation analysis is not required.

Both the counties and the state regulate and permit larger wastewater treatment systems (e.g., three or more houses, larger subdivisions, and city systems). Larger systems must meet the design requirements specified in MDEQ Circular 4 and the rules and prohibitions described in ARM 17.36.3 (Subdivision Requirements). MDEQ issues ground water discharge permits (under the Montana Ground Water Pollution Control System Rules, ARM 17.30.10) to certain types of larger onsite systems. Typically, systems with a design flow over 5,000 gpd are required to obtain a discharge permit if they are new or modified after May 1, 1998. Montana DEQ also inspects the systems that are permitted by the state (Personal Communications, Eric Regensburger, June 12, 2006). The two counties then issue the permits to construct and maintain the larger treatment systems. The counties are also responsible for conducting a nondegradation analysis, per the requirements in ARM 17.30.7 and the guidelines in the MDEQ document, “How to Perform a Nondegradation Analysis for Subsurface Wastewater Treatment Facilities,” (MDEQ, 2005).

The full regulations, circulars, and guidance pertaining to all SWTS can be found in the documents summarized in Table 1. Regulations for Montana, Lewis and Clark County, and Jefferson County are further discussed in the following sections (Sections 2.1, 2.2.1, and 2.2.2, respectively).

Table 1. State and County regulations and guidance pertaining to subsurface wastewater treatment systems

Document	Title	Online Location	Purpose
ARM 17.36.9	On-Site Subsurface Wastewater Treatment Systems	http://www.deq.state.mt.us/ dir/legal/Chapters/Ch36-toc.asp	Montana rules and regulations for small, privately owned SWTS. Specifies setback requirements, minimum depth to groundwater requirements, and septic size requirements.
ARM 17.36.3	Subdivision Requirements	http://www.deq.state.mt.us/ dir/legal/Chapters/Ch36-toc.asp	Montana rules and regulations for larger SWTS. Specifies setback requirements, minimum depth to groundwater requirements, and allowable systems.
ARM 17.30.5	Mixing Zones in Surface and Ground Water	http://www.deq.state.mt.us/ dir/legal/Chapters/Ch30-toc.asp	Montana rules and regulations for groundwater mixing zones
ARM 17.30.7	Nondegradation of Water Quality	http://www.deq.state.mt.us/ dir/legal/Chapters/Ch30-toc.asp	Montana rules and regulations for determining if a system needs to have a nondegradation analysis performed.
ARM 17.30.10	Montana Ground Water Pollution Control System	http://www.deq.state.mt.us/ dir/legal/Chapters/Ch30-toc.asp	
Montana DEQ Circular 4	Montana Standards For Subsurface Wastewater Treatment Systems	http://www.deq.state.mt.us/ wqinfo/Circulars.asp	Provides specifications for Montana DEQ approved systems.
Montana Nondegradation Guidelines	How to Perform a Nondegradation Analysis for Subsurface Wastewater Treatment Facilities	http://www.deq.state.mt.us/ wqinfo/Nondeg/HowToNonDeReg.asp	Provides guidance for conducting a nondegradation analysis. A companion document to ARM 17.30.7.
Lewis and Clark County Regulations	On-site Wastewater Treatment Regulations	http://www.co.lewis-clark.mt.us/ health/index.php	Specifies the Lewis and Clark County SWTS regulations and summarizes the permitting process.
Jefferson County Regulations		Not Available	Specifies the Jefferson County SWTS regulations and summarizes the permitting process.

2.1 State Regulations

The State of Montana has general, antidegradation, and design regulations for onsite wastewater treatment systems. The following sections summarize these regulations.

2.1.1 General Regulations

Onsite wastewater treatment system regulations for the state of Montana are contained in the Administrative Rules of Montana (ARM) 17.36.9 (On-Site Subsurface Wastewater Treatment Systems) and ARM 17.36.3 (Subdivision Requirements). The general scope of these rules is to, "protect the public health, safety, and welfare by setting forth minimum standards for the construction, alteration, repair, extension, and use of wastewater treatment systems within the state," (ARM 17.36.911). In general, the state regulations contained in ARM 17.36.3 and 17.36.9 prohibit on-site subsurface wastewater treatment systems from (1) contaminating state waters, and (2) causing a public health hazard. The following rules also apply to all onsite treatment systems in the State of Montana:

- All wastewater treatment systems must be designed and constructed in accordance with the applicable requirements in ARM 17.36.913 and in department Circular DEQ-4, 2004 edition (i.e., Montana Standards For Subsurface Wastewater Treatment Systems) (ARM 17.36.914(1)).
- Wastewater treatment systems must be located to maximize the vertical separation distance from the bottom of the absorption trench to the seasonally high ground water level, bedrock, or other limiting layer, but under no circumstances may this vertical separation be less than **four feet** of natural soil (ARM 17.36.914(3)).
- A replacement area or replacement plan must be provided for each new or expanded wastewater treatment system. (ARM 17.36.914(4)).
- A site evaluation must be performed for each wastewater treatment system. (ARM 17.36.914(5)).
- If a department-approved public collection and treatment system is readily available within a distance of 200 feet of the property line for connection to a new source of wastewater, or as a replacement for a failed system, and the owner or managing entity of the public collection and treatment system approves the connection, wastewater must be discharged to the public system (see ARM 17.36.914(6) (a) and (b) for additional details).

Regardless of the type, all treatment systems must meet minimum setback distances as defined in ARM 17.36.918 (see Table 2). Setbacks range from 10 to 100 feet, depending on the structure and the type of treatment system.

Table 2. Minimum setback distances for onsite wastewater treatment systems.

Structure	Single User Systems		Multiple User Systems	
	Sealed or Other Components[1,2] (ft)	Absorption Systems[3] (ft)	Sealed or Other Components[1,2] (ft)	Drainfield/Sand Mounds (ft)
Public or multi-user wells/springs	100	100	100	100
Other wells	50	100	50	100
Suction lines	50	100	50	100
Cisterns	25	50	25	50
Roadcuts, escarpments	10[4]	25	10[4]	25
Slopes > 25%[5]	10[4]	25	10[4]	25
Property boundaries	10	10	10	10
Subsurface drains	10	10	10	10
Water lines	10	10	10	10
Drainfields/ sand mounds[3]	10	-	10	-
Foundation walls	10	10	10	10
Surface water, Springs	50	100	50	100
Floodplains	--[1] 100[2]	100	--[1] 100[2]	100

[1] Sealed components include sewer lines, sewer mains, septic tanks, grease traps, dosing tanks, pumping chambers, holding tanks and sealed pit privies. Holding tanks and sealed pit privies must be located at least 10 feet outside the floodplain or any openings must be at least two feet above the floodplain elevation.
[2] Other components include intermittent and recirculating sand filters, package plants, and evapotranspiration systems.
[3] Absorption systems include absorption trenches, absorption beds, sand mounds, and other drainfield type systems that are not lined or sealed. This term also includes seepage pits and unsealed pit privies.
[4] Sewer lines and sewer mains may be located in roadways and on steep slopes if the lines and mains are safeguarded against damage.
[5] Down-gradient of the sealed component, other component, or drainfield/sand mound.

2.1.2 Design, Preparation, and Installation Regulations

Besides the regulations contained in the Administrative Rules of Montana, Montana DEQ Circular 4 provides regulations for the design, preparation, and installation of all on-site wastewater treatment systems (MDEQ, 2004). All treatment systems in the State of Montana must meet the minimum requirement set forth in Montana DEQ Circular 4. Regulations are provided for site evaluations, site modifications, wastewater flow, and design and placement of the wastewater treatment systems. The process for conducting site evaluations and selecting a treatment system is regulated by the counties (i.e., Lewis and Clark or Jefferson Counties). Additional regulations for the selection, design, and placement of multiple user systems are described in ARM 17.36.320 through ARM 17.36.327.

2.1.3 Antidegradation Regulations

Antidegradation regulations, as described in ARM 17.30.7, apply to subsurface wastewater treatment systems (SWTS). A SWTS is considered to create significant or non-significant changes to water quality based on the rules described in Figure 1. In addition to the regulations specified in Figure 1, a nonsignificant SWTS must also meet one of the 5 categories described in Table 3. If a system is deemed "nonsignificant", no additional analyses are required. If a system potentially creates a "significant" change to water quality, then a nondegradation analysis must be performed. The analysis must follow the guidelines in ARM 17.30.7 and the Montana DEQ document, "How to Perform a Nondegradation Analysis for Subsurface Wastewater Treatment Facilities," (MDEQ, 2006). Per these regulations, a nitrate sensitivity analysis and a phosphorus breakthrough analysis must be performed to determine if nondegradation thresholds are met.

Table 3. Categories for determining the significance of a SWTS.

Category	Description
1	• The lot size is two acres or larger; • The percolation rate is 16 minutes per inch or slower, if a percolation test has been conducted for the drainfield; • The natural soil beneath the absorption trench contains at least six feet of very fine sand, sandy clay loam or finer soil; and • The depth to bedrock and seasonally high ground water is eight feet or greater.
2	• The drainfield is pressure-dosed; • The lot size is two acres or larger; • The percolation rate is six minutes per inch or slower, if a percolation test has been conducted for the drainfield; • The natural soil beneath the absorption trench contains at least six feet of medium sand, sandy loam or finer soil; and • The depth to bedrock and seasonally high ground water is 12 feet or greater;
3	• The drainfield is pressure-dosed; • The lot size is one acre or larger; • The subdivision consists of five lots or fewer; • There is no existing or approved SWTS within 500 feet of the subdivision boundaries; • The percolation rate is six minutes per inch or slower, if a percolation test has been conducted for the drainfield; • The natural soil beneath the absorption trench contains at least six feet of medium sand, sandy loam or finer soil; and • The depth to bedrock and ground water is 100 feet or greater.
4	• The total number of subdivision lots that were reviewed pursuant to 76-4-101 et seq., MCA, and were created in a county during the previous 10 state fiscal years is fewer than 150; and • The lot is not within one mile of the city limits of an incorporated city or town with a population greater than 500 as determined by the most recent census; or
5	• The SWTS is a level II system; • The lot size is two acres or larger; 17-2798 12/31/03 • The bottom of the drainfield absorption trenches is not more than 18 inches below ground surface; and • The depth to limiting layer (based on test pit data) is greater than six feet below ground surface.

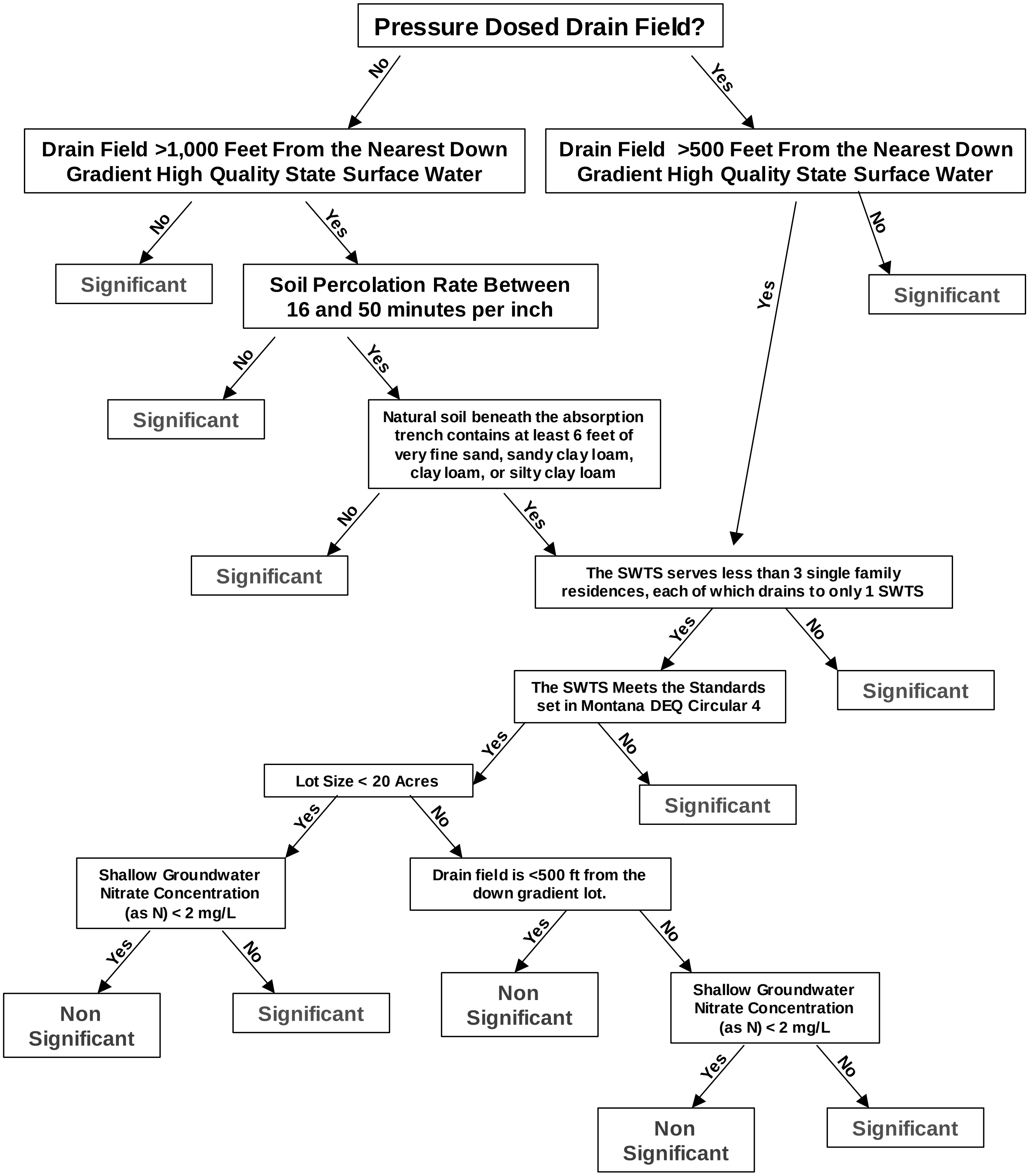

Figure 1. Method for determining the nondegradation significance of subsurface wastewater treatment systems in Montana.

2.1.4 Permitting

Montana DEQ issues ground water discharge permits (under the Montana Ground Water Pollution Control System Rules, ARM 17.30 subchapter 10) to certain types of onsite septic systems. Typically, systems with a design flow over 5,000 gpd are required to get a discharge permit (although there are other systems that also require a permit pursuant to ARM 17.30.1022) if they are new or modified after May 1, 1998. Montana DEQ inspects the systems that are permitted by the state (Personal Communications, Eric Regensburger, June 12, 2006). City or county authorities issue all other permits.

2.2 County Regulations

Reviewing authorities can also adopt their own onsite wastewater treatment regulations. In the case of the Lake Helena watershed, Lewis and Clark County and Jefferson County both have regulations governing these systems. Per the state regulations (ARM 17.36.911(2)), local regulations may not be any less stringent than the regulations contained in ARM 17.36.3 and 17.36.9. However, variances may be granted by the local permitting entities as long as the variance does not result in a threat to human health or state waters (ARM 17.36.922 and 17.36.924). ARM 17.36.3 and 17.36.9 also gives counties and cities authority to develop more stringent regulations for onsite wastewater treatment selection, design, installation, and operation. The regulations for Lewis and Clark and Jefferson Counties are described in Sections 2.2.1 and 2.2.2, respectively.

2.2.1 Lewis and Clark County Regulations

Onsite wastewater treatment system regulations for Lewis and Clark County are defined in the report titled, “Onsite Wastewater Treatment Regulations,” and are administered by the county Board of Health’s Environmental Division (Lewis and Clark County, 2006). Similar to the state, Lewis and Clark County regulations prohibit contamination of state waters, and prohibit treatment systems from creating a human or animal heath hazard. Site design, preparation, and installation must also meet the regulations specified in the Montana DEQ Circular 4, ARM 17.36.9 (On-Site Subsurface Wastewater Treatment Systems), and ARM 17.36.3 (Subdivision Requirements).

Lewis and Clark County also has additional, more stringent regulations regarding the selection and placement of wastewater treatment systems. The following regulations apply only to Lewis and Clark County (adapted from Lewis and Clark County, 2006, Section 4.3):

- Mounds and sand filters or Level 2 treatment is required in those areas where:
    - Groundwater occurs at less than five and a half feet to ground surface as determined by groundwater observation during high groundwater season; and,
    - Analysis of soils by the Department or the Soil Conservation Service soils limitation ratings for septic tank absorption fields is severe.
- Pressure-dosed and sand-lined trenches or Level 2 treatment will be required in those areas where:
    - The depth to seasonally high ground water level is less than six feet from the bottom of the drain rock; and,
    - The percolation rate is faster than three minutes per inch.

- Level 2 treatment is defined as, “a SWTS that: (a) removes at least 60% of total nitrogen as measured from the raw sewage load to the system; or (b) discharges a total nitrogen effluent concentration of 24 mg/L or less.”

As of October 15, 2005, only four systems were approved for Level 2 treatment – Recirculating Sand Filter; Orenco – AdvanTex; Fluidyne – Eliminite; International Wastewater Systems model 6000 sequencing batch reactor (MDEQ, 2005).

The Lewis and Clark County regulations (Sections 3 and 8) give the county authority to (1) issue permits for the construction or repair of wastewater treatment systems, (2) inspect systems to determine compliance with regulations, and (3) provide notice, require action, and issue penalties for failing systems. Before issuing a permit, a detailed site evaluation must be completed based on the county requirements. All other regulations governing the location, preparation, operation, or installation of wastewater treatment systems are similar to the state regulations summarized in Section 2.1 and described in MDEQ Circular 4.

2.2.2 Jefferson County Regulations

Onsite wastewater treatment system regulations for Jefferson County are defined in the report titled, “A Regulation Governing the Onsite Treatment of Wastewater in Jefferson County,” and are administered by the county Board of Health (Jefferson County, 2006). Similar to the state, Jefferson County regulations prohibit contamination of state waters, and prohibit treatment systems from creating a human or animal heath hazard. Site design, preparation, and installation must also meet the regulations specified in the Montana DEQ Circular 4, ARM 17.36.9 (On-Site Subsurface Wastewater Treatment Systems), and ARM 17.36.3 (Subdivision Requirements). Overall, the Jefferson County regulations are similar to the State of Montana’s (personal communications, Megan Bullock, June 13, 2006).

3.0 Conventional Wastewater Treatment Systems

Wastewater can be treated and dispersed to the environment through a variety of technologies that employ biological, physical, and chemical processes to digest, neutralize, or otherwise remove pollutants. Centralized wastewater facilities collect, transport, and treat sewage from dozens or hundreds of homes and businesses, while decentralized facilities provide similar services to individual or clustered buildings. Both types – centralized and decentralized – can discharge to surface waters or to the soil, but typically centralized facilities (i.e., conventional sewage treatment plants) will discharge treated effluent to a body of water, while decentralized systems discharge to soil absorption (infiltration) areas.

The Lake Helena watershed has a variety of systems from ranging from individual on-site treatment to large, centralized systems (i.e., Helena and East Helena treatment facilities). Nutrient removal varies with each system. The following sections summarize the various types of treatment systems and their nutrient removal efficiencies.

3.1 Conventional Onsite Systems

Individual onsite treatment systems consist of a septic tank and a subsurface soil absorption field. Buried in the ground, septic tanks are essentially watertight single or multiple chamber sedimentation and anaerobic digestion tanks. They are designed to receive and pretreat domestic wastewater, mediate peak flows, and keep settleable solids, oils, scum, and other floatable material out of the absorption field. Wastewater effluent is discharged from the tank and passes to the soil via a series of underground perforated pipes, perforated pipe wrapped in permeable synthetic materials, leaching chambers, pressure drip irrigation pipes or tubing, or other distribution system. From there, the partially treated effluent flows onto and through the developing biomat located at the soil infiltrative surface, and finally into the soil itself. Treatment occurs in the septic tank, on and within the biomat that forms at the soil infiltrative surface, in the soil, and continues as the effluent moves through the underlying soil toward groundwater or nearby surface waters.

Nitrogen in domestic wastewater can be removed through effective linking of aerobic and anaerobic biochemical transformation processes, but in general most conventional septic systems are not considered effective in removing nitrogen without additional treatment in the soil. Septic tanks remove 1 to 30 percent of the nitrogen in raw domestic wastewater (see Table 4). Percolation through 3 to 5 feet of soil can remove an additional 0 to 40 percent of the total nitrogen in septic tank effluent. Additional nitrogen removal is possible under optimum soil and denitrification (e.g., anaerobic and carbon-rich) conditions. Factors that favor denitrification in soil absorption fields include fine-grained soils such as silts and clays, layered soils that feature alternating fine-grained and coarse-grained layers, and organic matter or sulfur compounds in the infiltrative medium. Placing the soil absorption field high in the soil profile where organic matter is more likely to exist and dosing effluent to achieve alternating wet/dry (anaerobic/aerobic) cycles can aid denitrification and reduce nitrate leaching.

Most conventional septic systems are effective in removing phosphorus from effluent. Phosphorus precipitation can occur in the septic tank, and favorable phosphorus removal conditions (i.e., conditions favoring adsorption and precipitation reactions) exist for most soils of the United States. Combined, between 0 and 100 percent of phosphorus can be removed by a conventional treatment system (see Table 4). Phosphorus loading problems can occur in areas with older systems, highly permeable soils (e.g., sands), mineral-poor soils, nearby surface waters, and high system densities (USEPA, 2005).

Table 4. Nutrient concentrations and percent removal from conventional onsite treatment systems.

Type of System	% N Removal	N Concentration of the Effluent	% P Removal	P Concentration of the Effluent
Conventional Septic Tank	10-20% (USEPA, 2002) 28% (USEPA, 1993)	40 to 100 mg/L (Siegrist et al., 2000) 12-453, median 68 mg/L (McCray et al., 2005) 44.2 mg/L (USEPA, 2002)	57% (USEPA, 1993)	7.2–17.0 mg/L (Anderson et al., 1994.) 5-15 mg/L (Siegrist et al., 2000) 1.2-21.8, median 9 mg/L (McCray et al., 2005) 8.6 mg/L (USEPA, 2002)
Adsorption Trenches	10-20% (Siegrist et al., 2000)		0-100% (Siegrist et al., 2000)	0.01–3.80 mg/L (Anderson et al., 1994.)

3.2 Clustered and Centralized Systems

Cluster systems typically serve fewer than a hundred homes, but they can serve more. Under this approach, septic tank effluent from each home is collected and routed to another site for further treatment. Collection and movement of effluent to the final treatment site can be accomplished by gravity flow or pumps. The off-site treatment facility resembles a downsized centralized treatment plant, using similar technologies such as trickling (media) filters, aerobic lagoons, constructed wetlands, etc. Final dispersal of treated effluent is usually to the soil, due to greater treatment advantages and avoidance of NPDES permitting, monitoring, reporting, and other requirements.

Centralized wastewater service is characterized by 1) the system of piping which collects sewage at each home or facility and transports it to a central location, and 2) the central treatment facility, which typically discharges to a nearby body of water, but can discharge to the land (subsurface infiltration area, sprayfield) if conditions are favorable. Centralized systems generally consist of:

- Continuous flow, suspended growth aerobic treatment, usually in an open, aerated tank
- Fixed film treatment, with wastewater distributed over rock, gravel, sand, fabric, peat, plastic, or other media
- Sequencing batch reactors, sequential suspended growth treatment through an intermittent or continuous flow process
- Ponds, lagoons, and wetlands, which combine suspended and attached growth biological treatment with physical and other processes

Table 5 summarizes various types of cluster and centralized systems and typical nutrient treatment efficiencies.

Table 5. Nutrient concentrations and percent removal from clustered and centralized treatment systems.

Type of System	% N Removal	N Concentration of the Effluent	% P Removal	P Concentration of the Effluent
MLE Process – continuous flow, suspended growth process with an initial anoxic stage followed by an aerobic stage	~ 80	10 mg/L	~80-90	2 mg/L 1 mg/L with filtration
Four-Stage Process – continuous flow, suspended growth process with alternating anoxic/aerobic/anoxic/aerobic stages	~ 80-90	10 mg/L 6 mg/L with filtration	~80-90	2 mg/L 1 mg/L with filtration
Three Stage Process – continuous flow, suspended growth process with alternating aerobic/anoxic/aerobic stages	~ 80-90	10 mg/L 6 mg/L with filtration	~80-90	2 mg/L 1 mg/L with filtration
SBR Suspended Growth Process – batch process sequenced to simulate the four-stage process	~85	8 mg/L	~80-90	2 mg/L 1 mg/L with filtration
Intermittent Cycle Process – modified SBR process with continuous influent flow but batch, four stage, treatment process	~ 80-85	10 mg/L 8 mg/L with filtration	~80-90	2 mg/L 1 mg/L with filtration
MLE and Deep Bed Filtration Process – alternate 1 followed by attached growth denitrification filter	~ 90	6 mg/L – includes filtration	~ 90	1 mg/L – includes filtration
Submerged Biofilter Process – continuous flow or intermittent cycle process using one or more submerged media biofilters with sequential anoxic/aerobic stages	~75	12 mg/L	~80-90	2 mg/L 1 mg/L with filtration
RBC Process – continuous flow process using RBCs with sequential anoxic/aerobic stages	~ 75	12 mg/L	~80-90	2 mg/L 1 mg/L with filtration
Conventional Secondary Treatment – continuous flow activated sludge process (no enhanced nutrient removal; included for basis of comparison)	~ 50-60	20 – 25 mg/L	~ 30	7 mg/L

Adapted from Goess et al., 1998.

4.0 Alternative Wastewater Treatment Systems

Alternative or innovative systems such as mound systems, fixed-film contact units, wetlands, aerobic treatment units (“package plants”), low-pressure drip applications, and cluster systems are used in areas where conventional soil-based systems cannot provide adequate treatment of wastewater effluent. Areas that might not be suitable for conventional systems are those with nearby nutrient-sensitive waters, high densities of existing conventional systems, highly permeable or shallow soils, shallow water tables, large rocks or confining layers, and poorly drained soils.

Alternative or innovative systems feature components and processes designed to promote degradation and/or treatment of wastes through biological processes, oxidation/reduction reactions, filtration, evapotranspiration, and other processes. System summaries are shown in Table 6.

Table 6. Common alternative onsite treatment systems.

Type of System	% N Removal	N Concentration	% P Removal	P Concentration
Elevated/Mound Systems	44% (USEPA, 1993)	52.9 mg/L (calc[1])	10-90% (USEPA, 2002)	1-10 mg/L (USEPA, 2002)
Intermittent sand/media filters	15 to 35% (USEPA, 2002) 55% (USEPA, 1993)	42.5 mg/L (calc[1])	80% (USEPA, 1993)	~2 mg/L (USEPA, 2002)
Recirculating Sand/Gravel Filters	40-50% 64% (USEPA, 1993) 15-84% (California Regional Water Quality Control Board, 1997)	34 mg/L (calc[1]) 10-47 mg/L (California Regional Water Quality Control Board, 1997)	80% (USEPA, 1993)	~ 2 mg/L (USEPA, 2002)
Aerobic Treatment Units	24-61% (California Regional Water Quality Control Board, 1997)	37-60 mg/L (California Regional Water Quality Control Board, 1997)	30% (USEPA, 2002)	~ 7 mg/L (USEPA, 2002)
Constructed Wetlands	60%	20-35 mg/L	50% (USEPA, 2002)	~ 5 mg/L (USEPA, 2002)
Sequencing Batch Reactor	60% (Ayres Associates, 1998)	15.5 mg/L (Ayres Associates, 1998)	up to 80% (NEIWPCC, 2005)	~ 2 – 5 mg/L (NEIWPCC, 2005)
Nitrex	96% (Rich et al, 2003)	2.2 mg/L (Rich et al, 2003)	Up to 75% with modifications	~ 2 – 5 mg/L
Ruck System	29-54% (Brooks, 1996) (Gold et al, 1999)	18-53 mg/L (Brooks, 1996) (Gold et al, 1999)	~ 60-85%	~ 2-4 mg/L

[1]Calculated values: back-calculate raw load from McCray median and USEPA (1993) efficiency; then calculate resultant concentration for other systems using USEPA (1993) efficiency.

5.0 Treatment System Cost

Wastewater treatment cost varies widely based on the type of available and allowed systems. For individual onsite systems, installation costs for wastewater treatment can vary between $2,000 and $20,000 (see Table 7), and each system has additional associated maintenance costs. In comparison, costs for providing centralized sewer service for areas of new or existing development vary widely, depending on density of housing, pipe trenching conditions, the need for manholes and pumping stations, and capital costs for the construction or expansion of the central sewage treatment plant. It is generally less expensive to serve higher densities of housing (e.g., 2 to 6 homes per acre) because there are more connections per mile of sewer line. New treatment plant design and construction can cost $5,000 to $15,000 per house, with sewer line collection costs adding $10,000 to $20,000 or more per house for development on large lots (e.g., 3-5 acres). Homeowners then pay monthly rates for using the system. In the City of Helena, current sewer rates are $4.42 per month for the basic sewer service and $0.31 per hcf of water (City of Helena, 2006).

Monthly usage fees for centralized treatment are sometimes considered to be more accepted by the public, but most users know little about their wastewater treatment system and will pay regular operation/maintenance fees if they can avoid responsibility for large capital costs, such as a new septic tank or lateral line. Regarding other impacts, construction of the collection lines and the centralized treatment plant can cause localized sediment impacts, and operation of those lines over the long term can present challenges in terms of controlling inflow, infiltration, and leakage. Centralized treatment can also lead to unplanned development spurred by the need to recover capital costs required to build and operate centralized plants (Rocky Mountain Institute, 2004).

Table 7. Installation costs for onsite wastewater treatment systems.

Type of Onsite System	Installation Cost	% Cost Increase From Conventional Treatment
Conventional Septic Tank	$2,000-6,000 ($4,000 Average)	--
Adsorption Trenches	$4,000-$7,000	38%
Elevated/Mound Systems	$7,000-12,000	138%
Intermittent sand/media filters	$5,000-$10,000	88%
Recirculating sand/media filters	$8,000-$11,000	138%
Aerobic Treatment Units	$3,000-$6,000	13%
Constructed Wetlands	$10,000-$20,000	275%
Sequencing Batch Reactor	$8,500-$11,000	144%

6.0 Comparison of Systems

Centralized treatment is often viewed as providing more reliable and superior treatment, but upon closer examination both approaches – centralized and decentralized – offer excellent pollutant removal capabilities for the full range of pollutant parameters, at somewhat comparable costs (see Section 5.0). Table 8 compares the nitrogen and phosphorus treatment capabilities of the systems discussed in this report. In general, onsite systems with subsurface drainage are excellent at removing phosphorus, but not nitrogen. More advanced onsite systems or cluster systems can then improve nitrogen removal up to 75 percent. Centralized wastewater treatment facilities can achieve up to 90 percent reductions in both phosphorus and nitrogen with three and four stage processes. However, facilities with only primary or secondary treatment generally remove fewer nutrients than a conventional septic tank with an absorption field.

Overall, collection systems can be the most economical and effective method for treating wastewater. However, this assumes that there are (a) high housing densities, and (b) advanced wastewater treatment. Collection systems can be expensive and less effective than septic systems if these two conditions are not met.

Table 8. Comparison of treatment system cost and nutrient treatment.

Facility Type	Nitrogen Reduction Potential	Phosphorus Reduction Potential	Treatment Facility Cost Per House	Collection System Cost Per House	Avg. Yearly Wastewater Treatment Costs
Individual Septic System – Basic	Low	Moderate to High	$2,000 – 6,000	None	$25
Individual System – Mechanized (due to site constraints)	Low	Moderate to High	$6,000 – 8,000	None	$150
Individual System – Advanced Treatment	Moderate	Moderate to High	$7,000 – 10,000	None	$200
Individual System – Advanced N Removal	Moderate to High	Moderate to High	$13,000 – 16,000	None	$275
Cluster System – High Density – Basic Treatment	Low	Moderate to High	$5,500 – 7,000	$1,000 – 2,000	$300
Cluster System – Low Density – Basic Treatment	Low	Moderate to High	$5,500 – 7,000	$2,500 – 4,000	$350
Cluster System – High Density – Advanced Treatment	Moderate to High	Moderate to High	$8,500 – 10,500	$1,000 – 2,000	$400
Cluster System – Low Density – Advanced Treatment	Moderate to High	Moderate to High	$8,500 – 10,500	$2,500 – 4,000	$425
Centralized System – Conventional WWTP	Low to Moderate	Low to Moderate	$2,000 – 4,000	$5,000 – 15,000	$450
Centralized System – Advanced Treatment WWTP	Moderate to High	Moderate to High	$3,000 – 6,000	$5,000 – 15,000	$450

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